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Original Research

The effect of ureterorenoscopy and retrograde intrarenal surgery procedures on renovascular hemodynamics

Endoscopy and renovascular hemodynamics.

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Abstract

Aim: The aim of this prospective clinical study was to evaluate the preoperative and postoperative intrarenal vascular parameters of the kidneys undergoing URS and RIRS operations and compare the outcomes with the results of the normal contralateral kidneys.

Materials and Methods: A total of 89 patients were included in the study. There were 42 and 47 patients in RIRS and URS groups respectively. The ureteral tract with stone formation was named as operated side, and the contralateral side was named as non-operated side. Preoperative gray-scale and CDUS measurements were obtained 24 h before and 8 h after the operations. The RI measurements were calculated from the upper pole, middle area, and the lower pole of the kidney and averaged.

Results: There was no statistically significant difference in the demographic and peroperative features between the two groups except for irrigation fluid volume. Preoperative mean RI values were higher than the contralateral non-operated side kidney but not statistically significant (p=0,346). The ΔRI values were higher on the operated side in RIRS group compared with URS according to the selected surgery method (p=0,041).

Discussion: Endoscopic stone surgery procedures increase renal vascular resistance by increasing intrarenal pressure. Therefore, we recommend reducing the use of irrigation fluids as much as possible during surgical applications.

Keywords

Retrograde Surgery; Ureteroscopy; Stone; Color Doppler; Resistive Index

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Introduction

Ultrasonography is a cheap, non-invasive, and easily applicable method to evaluate obstructive uropathy and urinary system stone disease. It also has advantages such as the absence of contrast material injection and ionizing radiation. Although the gray-scale USG provides important anatomic information, it is limited in terms of functional data. If there is no pyelocaliectasis, its use is limited and no distinction can be made between obstructive and nonobstructive dilatation of the renal collecting system [1-2]. Recently, nonenhanced helical computed tomography (CT) has become the primary radiological study for the evaluation of urinary system stone disease [3]. The use of color Doppler ultrasonography (CDUS) has been proposed for the clinical differentiation of obstructive and non-obstructive dilatation [4].

Color Doppler ultrasonography is an effective and non-invasive method for evaluating renal vascular function. The blood flow velocity in the small parenchymal arteries can be used to measure blood flow velocity in the kidney circulation. The resistive index (RI) value, which can be measured from an artery in the renal parenchyma by Doppler ultrasonography, is used to assess vascular resistance. Vascular resistance may increase in tubulointerstitial and vascular system diseases [5] and also due to endoscopic stone surgery.

Retrograde intrarenal surgery (RIRS) and ureterorenoscopy (URS) are endoscopic surgical procedures that can be safely applied in the treatment of urinary system stone disease. RIRS is one of the most common surgical procedures for stone treatment, especially for stones less than 2 cm in size. URS is a preferred method with low complication and high success rates in the surgical treatment of ureteral stones [6].

The aim of this prospective clinical study was to evaluate the preoperative and postoperative intrarenal vascular parameters of the kidneys undergoing URS and RIRS operations and compare the outcomes with the results of the normal contralateral kidneys.

Material and Methods

A total of 89 patients that admitted to our hospital and resulted in the decision for endoscopic stone surgery for ureter or kidney stones were included in this study. After the approval of the local ethics committee, the study was designed prospectively between February 2018 and June 2018 (2017-KAEK-189_2018.02.27_03). The informed consent form was obtained from all patients and an assessment was made in accordance with the Helsinki Declaration.

Patients were divided into two groups according to the chosen surgery method. Forty-two patients constituted RIRS group and 47 patients constituted URS group. Both groups were also evaluated according to the presence of stone formation. The ureteral tract with stone formation was named as operated side, and the contralateral side without stone formation was named as non-operated side. Patients with grade 1 hydronephrosis or without hydronephrosis were included in the study to prevent the increase of resistive index due to obstruction.

Complete urinalysis, urine culture, whole blood count and biochemistry tests were performed before the operation. Patients were evaluated by stone protocol computerized tomography (CT). While the stone sizes were calculated, the longest diameter of the stone on the CT was measured and recorded. The patient's age, gender, side of the operation, stone density, operation time, stone size, lithotripsy time, irrigation fluid volume and stone location were recorded for each patient. The time between starting endoscopy and end of JJ stent insertion was defined as operation time. The time between starting and ending of lithotripsy was recorded as lithotripsy time. Prophylactic intravenous 1 gr cefazolin was administered to all patients 30 minutes before the operation.

Patients were excluded from the study if they had open and/or endoscopic renal surgery history, vascular disease, vascular disease in imaging, kidney anomaly, hypertension, aged under 18 years, previous ESWL, stone size > 2cm, residual stones>3cm, cerebrovascular disease, hydronephrosis grade ≥ 2, diabetes mellitus, multiple stones, BMI ≥ 30kg/m2 and The American Society of Anesthesiologists (ASA) ≥ 3.

Surgical Procedure

All procedures were performed under general anesthesia. URS was preferred for stones in the distal, mid or proximal ureter. And RIRS was the choice for those in the ureteropelvic junction or renal stones. Firstly, the surgeon accessed the ureter by a 9.5 F ureteroscope (Karl Storz, Tuttlingen, Germany) for a safe dilatation under the guidance of a guidewire in all cases. The 7.5 F ureteroscope was used to reach the stone in URS procedure. UAS (Elite Flex, Ankara, Turkey) was placed in the ureter in all RIRS cases. A 7.5 F flexible ureteroscope (Flex-X2, Karl Storz, Tuttlingen, Germany) was used for RIRS. A 200 mm laser fiber (Ho YAG Laser; Dornier MedTech; Munich, Germany / Dornier Med-Tech GmbH, Medilas H20 and HSolvo, Wessling, Germany) was used for laser lithotripsy in both groups. Nitinol stone retrieval baskets were also used if necessary. At the end of the operation, a ureteral stent was placed in all patients. Operation time was defined from the beginning of cystoscopy to the end of ureteral stent placement. Intraoperative data were recorded. Patients were discharged on the first postoperative day if they had no complication.

Patients' renal hemodynamic parameters based on RI were obtained with color Doppler ultrasonography. All patients' data were collected both pre- and post-operatively by the same radiologist. The mean RI and ΔRI values of the patients were calculated and compared between the two groups.

CDUS measurements

All ultrasound measurements were done using LOGIQ 7 system (GE Healthcare, Milwaukee, WI, USA) equipped with a 3.5-Mhz convex array transducer. Preoperative gray-scale and CDUS measurements were obtained 24 h before the operations. Similarly, postoperative CDUS measurements were done 8 h after the surgery. To obtain the mean RI values of each kidney, the RI measurements are calculated from upper pole, middle area, and the lower pole of the kidney and averaged. The renal RI was calculated using the following formula: RI = (peak systolic velocity-end diastolic velocity)/ peak systolic velocity. The RI difference (ΔRI) was determined as follows: ΔRI = RI of the treated kidney preoperatively -postoperatively. The values of RI and ΔRI used for statistical analysis were averages of the mean measurements in the individual patients.

Statistical Analysis

Results were calculated using the Statistical Package for the Social Sciences, version 10.0 (SPSS; Chicago). Statistical analysis of the difference between RI values of patients with operated and non-operated kidneys in each group was made using the Chi-square test. The significance of the difference in the ΔRI and preoperative and postoperative creatinine levels were tested using the Wilcoxon Signed- Rank test as well. Statistically, p-values less than 0.05 were considered significant.

Results

The demographic and peroperative features of the patients are given in Table 1. The mean age was 42.7 and 42.8 years in RIRS group and URS group, respectively. There was no statistically significant difference between the two groups except for irrigation fluid volume. Mean irrigation fluid used 1780.95 ml and 1467.35 ml in RIRS and URS procedure, respectively (p=0.003). All patients' preoperative mean RI values were higher than the contralateral non-operated side kidney but not statistically significant (p=0,346) (Table 2) (Figure1). The ΔRI values were higher on the operated side in RIRS group compared with URS according to the selected surgery method (p=0,041) (Table 2) (Figure 2) statistically. There was no significant difference between the two groups on the contralateral non-operated side kidney (p=0,618) based on ΔRI values postoperatively (Table 2) (Figure 2).

Evaluation of preoperative and postoperative creatinine levels according to surgery methods are shown in Table 3. In URS group, postoperative mean creatinine level was significantly lower than preoperative creatinine level (p=0.024).

Table 1. The Demographic Values and Preoperative Features

	RIRS (n=42)	URS (n=47)	P- value
Age (±SD)	42.79±12.5	42.85±13.3	0.808
Gender (n,%)			
Male	31 (73.8%)	33 (70.2%)	0.888
Female	11 (26.2%)	14 (29.8%)	
Side of operation (n,%)			
Right	26 (61.9%)	23 (48.9%)	0.310
Left	16 (38.1%)	24 (51.1%)	
Stone Density (HU)(±SD)	988.33±353.8	972.91±411.1	0.879
Operation Time (min) (±SD)	35.0±15.0	34.7±19.9	0.641
Stone Size (mm)(SD±)	10.73±4.0	10.51±3.07	0.816
Lithotripsy time (min)	13.79±9.7	12.45±12.2	0.258
Irrigation fluid volume (mL)	1780.95±471.7	1467.35±555.3	0.003
Stone Location (n,%)	7 (16.7%)		
Upper Calix		0	
Middle Calix	9 (21.4%)	0	
Lower Calix	9 (21.4%)	0	
Pelvic	9 (21.4%)	0	
UPJ	8 (19.0%)	0	
Proximal Ureter	0	20 (42.6%)	
Mid Ureter	0	16 (34.0%)	
Distal Ureter	0	11 (23.4%)	

SD: Standard Deviation, mm: millimeter, HU: Hounsfield Unit, min: minute UPJ: Ureteropelvic Junction

Table 2. RI values of patients according to selected surgery method

	RIRS Group		URS Group	
	Operated side	Non-operated side	Operated side	Non-operated side
Preoperative	0.72	0.61	0.71	0.63
Postoperative	0.81	0.66	0.77	0.68
ΔRI	0.09	0.05	0.06	0.05

Table 3. Evaluation of preoperative and postoperative creatinine levels according to surgery methods.

	RIRS (n=42)	URS (n=47)	[a]P- Value
Preoperative creatinine (mean±SD)	0.90±0.20	0.89±0.26	0.548
Postoperative creatinine (mean±SD)	0.85±0.12	0.83±0.15	0.366
[b]P value	0.078	0.024	

SD: Standard Deviation, [a]Mann-Whitney U Test, [b]Wilcoxon Signed Ranks Test

Discussion

Urinary stones may adversely affect renal function depending on their localization. A common cause of reversible kidney failure is increased intrarenal pressure as a result of urinary tract obstruction [7]. The relationship between the pressure increase, renal blood flow changes, and RI evaluation with obstructive uropathy has been described by Platt et al. [8-9] The change in blood flow has been reported to be caused by vasoactive substances (endothelin, angiotensin 2, etc.) [4]. CDUS can be used to detect changes in renal blood flow caused by intrarenal resistance increase. Arcuate arterial blood flow measurements can be performed with CDUS to detect RI changes. It was shown that RI value was related to urinary obstruction; also intrarenal pressure and renal vascular resistance were related to filtration fraction and effective renal plasma flow [10-11].

Technical advances in the field of urinary stone surgery have improved the minimally invasive treatment option by reducing surgical trauma and increasing comfort [12]. However, during endoscopic surgical procedures, ureteral and intra-renal pressure may also increase. Increased intrarenal pressure may cause pyelolymphatic or pyelovenous backflow by retroperitoneal extravasation [13]. As a result, renal vascular resistance may be increased. Hemodynamic functions may be affected as a result of increased renal vascular resistance. Hemodynamic and functional effects have been reported mostly in percutaneous nephrolithotomy. In a study investigating the effects of standard and tubeless percutaneous nephrolithotomy techniques on renal blood flow, RI was found to be significantly lower in the lower calyx arteries in the tubless group. However, it has been reported that during the 10-month follow-up period, two techniques can cause almost equal damage [14]. In another study, it was reported that percutaneous single and multiple access had similar effects on renal function [15]. Although the literature shows the negative effects of obstruction on renal function, there is inadequate data on the functional effects of RIRS and URS procedures.

In a study of 47 patients who underwent URS procedure, Tokgöz et al. evaluated renal function with RI measurements 24 hours before and after the operation. In order to determine the effect of the surgical procedure on the kidney function, they included patients who had no obstruction or grade 1 ectasia. They concluded that RI values increased significantly in ipsilateral kidney. They also emphasized that RI change rate was

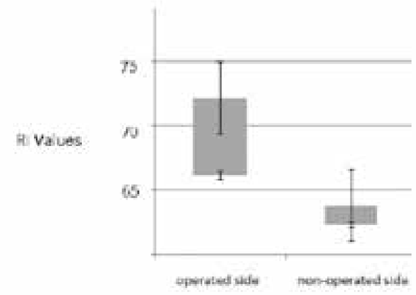

Figure 1. RI values of operated and non-operated kidneys.

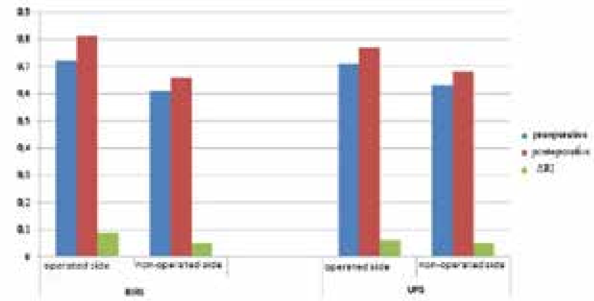

Figure 2. RI values of patients according to selected surgery method preoperatively and postoperatively.

significant compared to normal contralateral kidney [16]. Similarly, we included the patients with grade 1 hydronephrosis or without hydronephrosis. The mean RI value in the operated kidneys was significantly increased when compared with contralateral kidneys. In addition, the mean ΔRI value of the patients who underwent RIRS procedure was higher than in those who underwent URS procedure. This significance is attributed to the significantly higher amount of irrigation fluid used during surgery in patients undergoing RIRS.

In endoscopic surgeries, renal vascular resistance may be increased as a result of pyelovenous and pyelolymphatic reflux caused by increased intrarenal pressure due to irrigation use [16]. As a result, it can cause a significant increase in RI values postoperatively. Although there was no significant difference between the operation time and stone characteristics between the two groups, the use of irrigation fluid in the RIRS procedure was higher. In the RIRS procedure, significantly higher RI values than in the URS procedure can be explained by the higher amount of irrigation fluid used. In addition, mean postoperative creatinine level decreased in both groups. However, this decrease was significant in the URS group. This result suggested that the amount of irrigation fluid used was higher in the RIRS group, resulting in less creatinine reduction in this group.

Taking the contralateral kidney as a control group can be considered as a limitation of the study. In addition, due to the subjective evaluation of CDUS, the fact that the study is single-centered can be considered as another limitation.

In conclusion, endoscopic stone surgery procedures increase renal vascular resistance by increasing intrarenal pressure. It can be said that the most important factor is the amount of irrigation used. Therefore, we recommend reducing the use of irrigation fluids as much as possible during surgical applications. In addition, the prevention of distension by intermittent bladder decompression in prolonged cases may reduce the pressure increase. Further studies including comprehensive and long-term follow-up are needed to elucidate the effects of endoscopic surgical procedures on renal function and to develop new treatment modalities.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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